Charles University in Prague
Faculty of Education
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BACHELOR THESIS

Pre-fortis Shortening in Czech English

Samohlásková délka v české angličtině

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Declaration

I hereby declare that this bachelor thesis **Pre-fortis Shortening in Czech English** is my own work and that only the sources listed on the Works Cited page were used in its compilation. This work was not used to obtain another or the same university degree.

Prague, 20 July 2015

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Helena Hrychová

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ANOTACE

Tato bakalářská práce zkoumá roli zkracování vokálů před fortisovými konsonanty v české angličtině. Zkracování vokálů je fonetiky všeobecně přijímaný jev, který není příznačný pouze pro angličtinu, Matthew Chen dokonce naznačil, že by mohlo jít o jev jazykově univerzální. V angličtině se jedná o velmi významný úkaz, neboť bylo nejrůznějšími výzkumy prokázáno, že zde slouží jako ukazatel znělosti následující souhlásky. Předkládaná práce se zabývá tímto jevem v české angličtině, kde je předpokládáno, že délka vokálů souvisí s jazykovou úrovní mluvčího. Z tohoto důvodu bylo cílem zjistit do jaké míry 20 českých studentů rozdělených do dvou kategorií podle jejich úrovně angličtiny (A2, C1) využívá zkracování samohlásek a zda jejich jazyková úroveň má vliv na délky vokálů před fortisovými a lenisovými konsonanty. Studenti byli nahráni při čtení 40 anglických vět a jejich samohláskové délky byly porovnány s daty získanými pro dvě rodilé mluvčí.

KLÍČOVÁ SLOVA

česká angličtina, samohlásková délka, pre-fortisové zkracování, znělost, fortisové a lenisové konsonanty

ANNOTATION

This bachelor thesis examines the role of a phenomenon called pre-fortis shortening in Czech English. This term is used by phoneticians to represent the shortening of vowels before fortis consonants. It is not characteristic only of English, Matthew Chen even suggested that it could be a language-universal phenomenon. In English it is a very significant feature since English vowel duration was proven by various experiments to serve as a cue to the perception of the voicing characteristic of the following consonant. This thesis advances our understanding of pre-fortis shortening in Czech English where vowel duration was hypothesized to correlate with the speaker's proficiency in English. As a result, this work aims to examine the extent to which 20 Czech students divided into two categories depending on their English level (A2, C1) exploit this phenomenon and whether their proficiency has an impact on vowel durations before fortis and lenis consonants. They were recorded while reading 40 English sentences and their vowel durations were compared to those obtained from two native English speakers.

KEYWORDS

Czech English, vowel duration, pre-fortis shortening, voicing, fortis and lenis consonants

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INTRODUCTION

Over the past fifty years, English has become one of the most widely spoken and written languages in the world and a *lingua franca*. Nowadays, it is used as a means of communication which allows people from completely different cultural backgrounds to make themselves understood while having a discussion on various political, medical or economic topics. However, the more the importance of English as a global language increased, the more essential it became to master it even for non-native speakers who very often run into pronunciation problems that can subsequently cause misunderstandings.

One of these common difficulties English users encounter in the area of pronunciation, pre-fortis shortening, presents the main subject of this thesis. The author has repeatedly noticed that Czech learners tend to ignore vowel duration changes in corresponding contexts and would like to examine the extent to which their ability to do so correlates with their language proficiency.

It is widely acknowledged that vowels in a majority of languages are not distinguished solely by their quality but also by their quantitative differences and this is also true for English. Therefore, the first chapter of this thesis focuses on the quality of vocalic elements in English, particularly on their articulatory classification and acoustics. The second chapter, on the other hand, provides a broad overview of vowel duration, its function in both English and Czech and several factors which are supposed to have an impact on vowel quantity, particularly the phenomenon of pre-fortis shortening found in vowels followed by fortis consonants.

The empirical part of this thesis studies vowel duration in Czech English, especially the presence of pre-fortis shortening and its utilization by Czech students of English with respect to their language proficiency. The third chapter clarifies the creation of the text for recording and the questionnaire along with the characterization of the respondents, the description of the process of recording and the analysis of the obtained material. The last chapter presents the acquired results in relation to the speaker's proficiency in English and also some of the factors listed in the theoretical part, namely the voicing status of the following consonant, the inherent phonological factor and the manner and the place of articulation are discussed. The last two sections comment on the significance of the research findings and their possible implementation in teaching practice.

THEORETICAL PART

The theoretical part of this thesis focuses on the quality and quantity of English vowels and mainly on the factors which influence vowel duration, particularly the phenomenon known as pre-fortis shortening.

1 The quality of English vowels

Taking into consideration that English vowels are distinguished mainly by their quality, the first chapter of this thesis will focus on the qualitative differences of English vowels, their articulatory classification and acoustics.

1.1 Articulatory classification of vowels

English vowels are speech sounds created with no obstruction to the egressive airstream and with a greater degree of resonance in the supraglottal cavities – the mouth, pharyngeal and nasal cavities. These resonators are shaped by the movement of the lips, the soft palate and the tongue. Therefore, all vowels have to be described according to the degree of lip rounding, the position of the soft palate and the tongue (Cruttenden 34).

The IPA[1] uses a set of cardinal vowels[2] to define vowel qualities. Predominantly, charting vowels is done by using the vocalic quadrilateral representing the vowel space which studies lip posture, vowel height, frontness and backness for the vocalic description (Ogden 59).

The English vocalic system consists of 12 pure vowels and 8 diphthongs.[3] Pure vowels or monophthongs are sounds which do not glide towards a new position. They can be further divided according to the horizontal position of the tongue into front (/iː ɪ, e, æ/), where the tongue is positioned forward in the mouth; central (/ə, ɜː, ʌ/) and back (/ʊ, uː, ɒ, ɔː, ɑː/) vowels, where the tongue is positioned toward the back of the mouth. Another classification takes into account the vertical position of the tongue and divides the vowels into close, close-mid, open-mid and open (Roach 11, 12).

[1] International Phonetic Alphabet

[2] "Cardinal vowels are a set of reference vowels that have predetermined phonetic values. Other vowels are described with reference to the cardinal vowels.[…] [They] represent possibilities of the human vocal tract rather than actual vowels of a language because they are established on theoretical grounds" (Ogden 57).

[3] This vocalic system relates to the General British (GB) accent, formerly known as Received Pronunciation (RP). Cruttenden refers to General British since the pronunciation represented as RP changed significantly during the second half of the 20th century and the term RP is no longer satisfactory (80). For further information about GB, see Cruttenden 80-86.

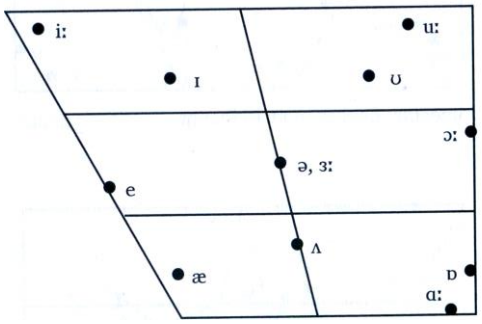

Figure 1. General British monophthongs (adapted from Ogden 69).

English diphthongs are described by Cruttenden as the sequences of two vocalic elements which "form a glide within one syllable" (140). As mentioned above, the vocalic system of General British standard contains 8 diphthongs further divided according to the direction of the glide into two groups: 5 closing diphthongs /eɪ, aɪ, ɔɪ, əʊ, aʊ/ which begin as open vowels and glide to a closer position, and 3 centring diphthongs /ʊə, ɪə, eə/ which glide from a more peripheral vowel to a more central one, schwa (Roach 17, 18). As far as their structure is concerned, they are formed by two elements and "most of [their] length is concentrated on the first element, the second element being only lightly sounded" (Cruttenden 140).

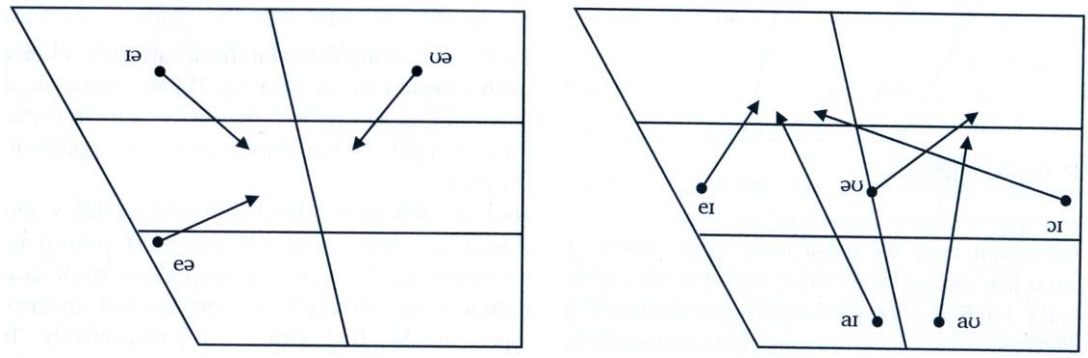

Figure 2. General British centring and closing diphthongs (adapted from Ogden 70, 71).

1.2 The acoustics of vowels

English vowels are musical sounds "conveyed to our ears by means of waves of compression and rarefaction of the air particles" (Cruttenden 19). Due to the alterations in pressure caused by the activity of a vibrator, the air particles start vibrating at the same rate. We can

distinguish between two types of vibrations. They can be represented by periodic[4] or aperiodic waveforms. The English vowels belong to the first group and are produced as tones (Cruttenden 19). Since periodicity is related to the vibration of the vocal cords[5], periodic waveforms are interconnected with phonation[6]. The waveform depicted in Figure 3 shows periodicity in the first part representing the front vowel /i:/ and aperiodicity in the following consonant, a voiceless fricative /f/.

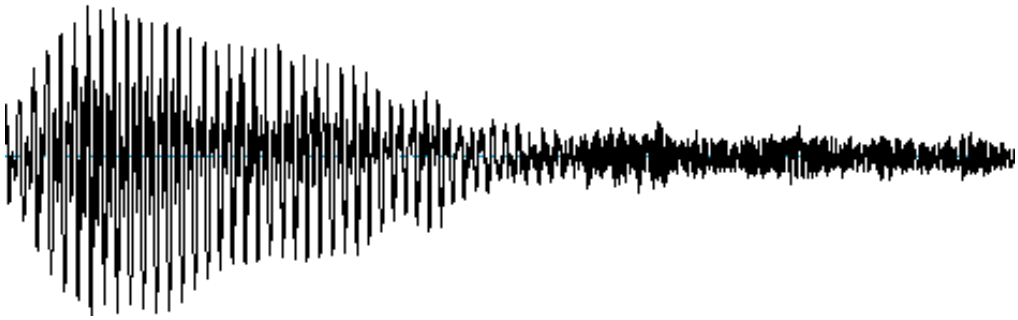

Figure 3. Periodicity and aperiodicity as displayed in the sequence /i:f/ in the word *leaf* (adapted from the C1_001 recording).

Another way of presenting sounds are three-dimensional spectrograms where periodic signals are represented by two visual properties, vertical striations and horizontal formants. The striations symbolize the opening of the vocal cords and the formants are natural resonances (Ogden 33).

Even though the spectrogram consists of more formants, "two, or at most three [of them] appear to be sufficient for the correct identification of vowels" (Cruttenden 21). "It is the pattern of formant frequencies and their relationship to one another that is important rather than the absolute values" (Ashby and Maidment 72). The first formant (F1) is related to vowel height and thus vowels described as close have a low F1 and vowels described as open have a high F1. The second formant is related to the frontness and backness of the tongue. High F2 can be found in front vowels where the tongue is raised in the front of the mouth; and low F2 appears in back vowels where the tongue is raised at the back of the mouth (Ogden 62, 63).

[4] "In reality they are not perfectly periodic, but for simplicity [they are thought of] as such" (Ogden 31).

[5] Vocal cords are "two fleshy folds which are stretched across the larynx. They can be held wide open, as in breathing; completely closed, as in a glottal stop or cough; or made to vibrate to produce voicing" (Ogden 179).

[6] Phonation = voicing; vocal cord vibration (Roach 25).

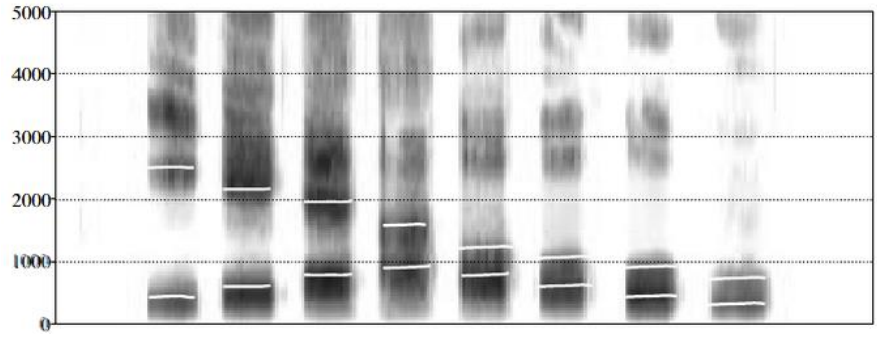

Figure 4. Spectrogram of primary cardinal vowels /i, e, ɛ, a, ɒ, ɔ, o, u/ (adapted from Ogden 63).

1.3 Methodological remark - acoustic and auditory aspects of sounds

While listening to someone's speech, "we perceive an ever-changing pattern of sound" (Cruttenden 18). This pattern is comprised of several variations. First of all, it is a variation of sound quality which allows us to hear a variety of speech sounds. Secondly, the pitch which helps us recognize the intonation or melody of the speech. Thirdly, we perceive sounds of different loudness and as a result, some sounds appear to be louder than others. And finally, a variation of length exists which allows us to perceive some sounds as longer or shorter than others (Cruttenden 18). These variations are related to the listener's perception of the sounds. However, it has to be mentioned that all these auditory properties of sounds also have their acoustic correlates. The quality or timbre corresponds to spectrum, the pitch to fundamental frequency (F_0) measured in Hz; and intensity measured in decibels is a correlate of loudness (Cvrček et al. 40, as translated and paraphrased by Helena Hrychová).

Nevertheless, before focusing thoroughly on vowel duration in English, a distinction has to be made also between the terms *duration* and *length*. To a listener, sounds in a language may seem to be of different *length*. However, *length* is only an auditory property of sound, it has to be measured by means of oscillograms or spectrograms to allow us to speak of *duration*. *Duration* represents the physical property of sound measured in milliseconds. But, it is not unusual that the acoustic variations of *duration* do not always correlate with our perception of *length* (Cruttenden 24).

2 The quantity of English vowels

As stated in the methodological remark, the auditory correlate of duration is length or quantity. Consequently, some syllables can be perceived as longer or shorter when compared to the others. "Such variations of length within the utterance constitute one manifestation of the rhythmic delivery which is characteristic of English and so is fundamentally different from the flow of other languages, such as French, where syllables tend to be of much more even length" (Cruttenden 24).

Naturally, each vowel in the English vocalic system has its inherent duration (Klatt 1213). Usually, vowel duration is described as the opposition between short /ʌ, e, æ, ɪ, ɒ, ʊ, ə/ and long /ɑː, ɜː, iː, ɔː, uː/ vowels (Cruttenden 97). However, this traditional distinction appears to be unreliable, since it implies that short vowels can never become shortened or lengthened which is incorrect. Roach emphasizes that their short or long character is only relative since English vowel duration depends partly on the context and vowels in different contexts have diverse length (13, 16).

Jones introduces a different classification of lax and tense vowels according to the degree of muscular tension of tongue and lips during their articulation. He describes tense vowels as those "which are supposed to require considerable muscular tension on the part of the tongue" and lax vowels as those "in which the tongue is supposed to be held loosely" (Jones 39). Lax vowels overlap with short and tense with long vowels.

As this work draws on both British and American studies concerning vowel duration, it is important to mention two major respects in which the durations of GA[7] and GB vowels differ. Firstly, in GB vocalic system, there is a much sharper contrast between the duration of short and long vowels. Wells states that "even the longest British short vowel averages shorter in duration than the shortest long vowel" as distinct from the GA standard where this contrast is not so noticeable (*Formants*). Secondly, in GA it is also possible to notice the differences in the distribution of vowels to the classes of short/long vowels. Wells points out that "/æ/ and /ɒ/ are short in British, though the corresponding American vowels /æ/ and /ɑ/ are long or indifferent" (*Formants*).

[7] General American is "that form of American which does not have marked regional characteristics" (Cruttenden 87).

2.1 Factors affecting vowel duration

As previously alluded to, vowel duration is not constant, it depends on many contextual factors. The influence of several of them was studied by many phoneticians over time (Lehiste and Peterson 1960, Wiik 1965, Luce and Charles-Luce 1985, Crystal and House 1988, Van Santen 1992 etc.). According to their studies, vowel duration is influenced by factors such as:

- inherent phonological vowel duration (the near-open front vowel /æ/ is intrinsically longer than the close-mid front vowel /e/ etc.)
- identity of the following segment (the near-close near-front vowel /ɪ/ when followed by fortis[8] consonant /t/ in *kit* is shorter than /ɪ/ followed by lenis consonant /d/ in *kid*; the centring diphthong /eɪ/ is shorter in *late* than in *laid* etc.)
- vowel position within the syllable and syllabic stress (vowels in stressed position tend to be longer than those in unstressed position)
- position of the syllable within the word (Van Santen states that "the duration of stressed vowels in word-initial syllables decreases as the number of syllables increases" (532).)
- location of the word within a sentence and its proximity to a syntactic boundary (syllables close to the word boundary tend to be longer than others)
- length of the word (vowel duration is longer in monosyllabic words than in polysyllabic words (Wiik 119))
- speaking rate
- emphasis and semantic novelty

Having mentioned the various factors, let us now focus on some of them in detail, namely the inherent phonological vowel duration, the identity of the following segment (manner/place of articulation and voicing characteristic of the consonant), the position of the vowel within a syllable, the location of the word within a sentence and the length of the word.

[8] English consonants can be further divided according to the muscular tension involved in their articulation into **fortis** (produced with greater force and energy) or **lenis** (produced with less energy and muscular effort) consonants (Cruttenden 31).

2.1.1 Inherent phonological vowel duration

As stated above, each sound has its own intrinsic phonological duration. For example, the vowels /ɪ, ɛ, ʌ, ʊ/ are considered to be shorter when compared to other English vowels (Lehiste and Peterson in Klatt 1213). The long vowels situated in identical environments are approximately 1.6-2.0 times longer than the short ones (Wiik 114).

In 1965, a Finnish phonetician Kalevi Wiik measured the average durations of 11 primary-stressed English monophthongs (the vowel schwa was not included in the test since it does not occur in a stressed position). The average durations indicated that there was almost no difference in the duration of diverse short vowels, however, there appeared to be a tendency indicating that the closer the vowel is, the shorter it gets. Vowels with the highest F1 (such as /ɔ/ or /ʌ/) were measured to be about 11% longer than those with the lowest F1 (/ɪ/ or /ʊ/). The close vowel /ɪ/ was the shortest with the duration of 120 ms, whereas the open vowel /ɒ/ was slightly longer (145 ms). The same effect was detected also for the long vowels. They were almost twice as long as the short ones with the shortest duration measured for the close back vowel /u:/ (206 ms) and the longest duration regarding both mid back long vowel /ɔ:/ and open back vowel /ɑ:/ (271 ms). As a result, Wiik concluded that "the lengthening effect of the sonority[9] of [vowels] is larger in the long [vowels] than in the short ones" (Wiik 120).

Vowel duration depending on the quality of vowels was also studied in American English. Luce and Charles-Luce in 1985 came to a similar conclusion as Wiik. In their experiment the duration of the open vowel /ʌ/ (179 ms) was significantly longer than that of the close vowel /ɪ/ (121 ms) (Luce and Charles-Luce 1951).

As far as the length of the diphthongs is concerned, they are considered to be of a similar length to the long vowels with their first segment longer and stronger than the second one (Roach 17). Wiik studied the duration of both closing and centring diphthongs in voiced and voiceless positions and he found "no systematic difference in duration between the various types of English diphthongs" (126). His results for diphthongs and both short and long vowels compared to the results of Wells for GB and Lehiste and Peterson and van Santen for GA can be seen in Table 1.

[9] Sonority is a "term referring to the carrying power of individual sounds" (Cruttenden 25).

Vowel	Vowel duration in ms			
	Wells (1962)	Wiik (1965)	Lehiste, Peterson (1960)	van Santen (1992)
ʌ	148	139	---	133
e	170	136	200	143
æ	210	196	330	208
ɪ	139	120	180	111
ɒ	178	145	---	190
ʊ	142	135	200	127
ə	---	152	230	105
ɜ:	309	247	---	---
i:	293	219	240	153
ɑ:	335	271	260	196
ɔ:	330	271	310	211
u:	294	206	260	156
eɪ	---	256	270	182
aɪ	---	281	350	203
ɔɪ	---	261	370	254
əʊ	---	244	220	---
aʊ	---	282	300	214

Table 1. The approximate average durations of English pure vowels and diphthongs adapted from Wiik (120, 124), Wells (*Formants*), Lehiste and Peterson (702) and van Santen (523). The Wiik's data for the diphthongs are only approximate, they were calculated from the Chart 22 on page 124.

2.1.2 Identity of the following segment and pre-fortis shortening

Phoneticians have long observed the fact that there is a cross-linguistic tendency for vowels to be longer before voiced consonants than before voiceless consonants. The effect of postvocalic consonants on vowel duration has been examined by many studies (House 1953, Lehiste and Peterson 1960, Wiik 1965, Chen 1970, Klatt 1976, Luce and Charles-Luce 1985, van Santen 1992 etc.). It was not evident whether the durational difference is a language-specific speech habit or whether it is conditioned by an inherent physiological feature of articulation. Owing to Matthew Chen's experiment concerning the cross-linguistic view of vowel length, it was discovered that "it is a language-universal phenomenon", however, "the extent to which an adjacent voiced or voiceless consonant affects its preceding vowel duration is determined by the language-specific phonological structure" (Chen 139). Chen

examined vowel length in four different languages, English, French, Russian and Korean and in all the studied languages "a vowel [was] invariably longer before a voiced consonant than before an unvoiced one" (Chen 135).

2.1.2.1 Voicing status of the following segment

First of all, as stated above, the duration of vowels has been demonstrated to vary depending on the voicing status of the following consonant. However, in English, voiced/voiceless consonantal pairs "are distinguished not only by the presence or absence of voice but also by the degree of breath and muscular effort involved in their articulation" (Cruttenden 31). Consonants articulated with less energy and muscular effort are usually referred to as lenis consonants and those which are always voiceless and which are articulated with more muscular effort are known as fortis consonants (Cruttenden 31).

Vowels tend to be shorter when followed by longer fortis consonants within the same syllable than when followed by shorter lenis consonants. This phenomenon is usually referred to as pre-fortis shortening or clipping. As a result, the /i:/ in *feet* undergoes the shortening, but the same vowel in *feed* maintains its original duration (Wells, *Syllabification* 78). Cruttenden refers to this phenomenon as to 'shortening' or 'reduction' (110). However, to J. C. Wells, these terms do not seem appropriate because according to him, "calling such sounds 'short' leads to confusion when pairs of phonemically distinct vowels such as /i:/ and /ɪ/ are also categorised as 'long' and 'short' respectively; calling them 'reduced' is to be avoided since this term for most phoneticians denotes change of quality" (*Syllabification* 78). As a result, he introduces the term pre-fortis clipping.

In 1953, House stated that vowels in voiced environments (preceded and followed by the same consonant) tend to be "longer in duration, longer in fundamental frequency, and greater in relative power" (House 113). Shortly afterwards, Lehiste and Peterson pointed out that "the average duration of the syllable nucleus before the voiceless member of the consonant pair was 197 ms, and before the voiced member was 297 ms" (700)[10]. They measured that "the ratio of vowel before voiceless consonant to vowel before voiced consonant is approximately 2:3 (700). Subsequently, in 1970, Chen investigated this tendency in various languages and he found out that each language manifests different ratio of mean vowel durations before voiceless/voiced consonants. As far as English was concerned, he came to a similar conclusion as Lehiste and Peterson with the ratio about 0.61 compared to higher

[10] Originally in centiseconds (csec).

ratios in Russian, Korean and French (0.78-0.89). The reason for this difference is probably the fact that English uses the distinction between vowel durations as a cue of the final consonant's voicing (Chen 138).

Vowels in Luce and Charles-Luce's experiment were 55 ms longer in words ending in voiced stops (177 ms) than those ending in voiceless stops (122 ms) (Luce and Charles-Luce 1951). Their results correspond to Wiik's calculations for short vowels which showed that short vowels are lengthened 67 to 72 ms when followed by a voiced consonant. For long vowels, this lengthening was approximately 141 to 179 ms (Wiik 116). In 1992 van Santen came to a similar conclusion as Wiik. He measured that the difference in the duration of pre-fortis and pre-lenis vowels can be up to 120 ms (van Santen 527) which is in accordance with the average for both short and long vowels in Wiik's study.

Even though the term pre-fortis shortening is usually associated only with vowel duration, it affects also preceding sonorants[11], notably the nasals /n, m/ and the lateral /l/. Volín points out that "not only is /ɪ/ in *built* realized as short [ɪ̆] while the same phoneme in *build* is longer [ɪ], but also /l/ in *built* comes out shorter than /l/ in *build*" (70).

Furthermore, Chen measured the duration of vowel plus sonorant sequences when followed by either voiced or voiceless consonants and he discovered that "the lengthening or shortening effect of the consonantal environment was not limited to the immediately preceding sonorant alone, but rather spread to the vowel segment as well; vowel duration varied notably even when separated from the obstruents[12] by an intervening sonorant" (150). According to him, "the voicing of the consonantal environment exercised durational influence on the vowel-sonorant sequences as a whole" (Chen 150). His measurements indicated that for example in the word *sent*, the duration of /e/ was approximately 218 ms and that of nasal /n/ was 51 ms, while in the word *send*, the duration of the vowel was slightly longer (245 ms) and the duration of the nasal increased even more significantly (133 ms) (Wiik 149). Some of his measurements for vowels followed by sonorants and voiced/voiceless consonants can be seen in Table 2.

[11] "Sonorants are those voiced sounds in which there is no noise component (i.e. voiced nasals, approximants and vowels)" (Cruttenden 31).

[12] Obstruents are the sounds "in whose production the constriction impeding the airflow through the vocal tract is sufficient to cause noise". "This category comprises plosives, fricatives and affricates" (Cruttenden 31).

Word	Duration in ms		
	Vowel	**Sonorant**	**Total**
	/e/	**/n/**	
sent	218	51	269
send	245	133	378
hence	179	38	217
hens	213	111	324
	/ɪ/ - /ɔ:/	**/l/**	
kilt	76	134	210
killed	105	231	336
false	97	203	300
falls	125	251	376
	/ɑ:/ - /ɜ:/	**/r/**	
cart	118	138	256
card	157	169	326
surf	53	164	217
serve	61	194	355

Table 2. Duration of vowels and sonorants before voiced/voiceless consonants (adapted from Chen 149).

Reflection on the explanation of pre-fortis shortening

Even though it is well documented in literature that vowels are longer in some environments than in others, phoneticians are still ambivalent as far as the explanation of this tendency is concerned. Taking into consideration Chen's suggestion that pre-fortis shortening is a language-universal phenomenon, it is expected that some inherent articulatory factor must exist which underlies these durational differences (Chen 139).

Several explanations for this tendency have been investigated by various authors over the last century. Jesperson proposed that "the duration of a vowel is function of its articulatory distance to the adjacent consonant" (quoted in Lindblom 22). However, Chen states that "the target position of buccal articulators is presumably identical for the voiced and the voiceless members of the consonant pair, and the presence or absence of voice is produced by a separate articulator altogether" (140). Chen also mentions the theory of Simon Belasco stating that "given that a fortis obstruent takes more force to produce, the anticipation of spending more energy on it shortens the preceding vowel" (Chen 140). Nevertheless, Chen disproved all these theories and offered his own suggestion that the difference in the duration

of vowels preceding consonants depends rather on the "rate of closure transition" from vowel to the consonant closure (157).

The influence of muscular activity governing the articulation of vowels preceding voiced and voiceless consonants was also investigated in 1975 by Raphael. He studied the EMG signals from the muscles which participate in the vowel production, such as orbicularis oris, depressor anguli oris and genioglossus muscle. His results indicated that "there was a greater duration of muscular activity in the articulations of vowels preceding voiced consonants than in those preceding voiceless consonants" (Raphael, "Physiological control" 30). His data confirm the hypothesis that "the acoustically measured durational differences long observed between vowels preceding voiced and voiceless consonants are primarily controlled physiologically by motor commands to the muscles governing the articulators which are active in the formation of vowels" (Raphael, "Physiological control" 32).

On the other hand, in 1976 Klatt proposed his own theory and he considered the durational difference to be "a result of the natural tendency to make a slightly early glottal opening gesture for a postvocalic voiceless consonant in order to insure that no low-frequency voicing cue is generated during the obstruent" (1213).

To conclude, despite numerous attempts to discover the inherent articulatory factor which would explain the durational differences between vowels followed by fortis/lenis consonants, none of these theories were proven to be absolutely infallible.

Pre-fortis clipping and syllabification

According to J. C. Wells, pre-fortis shortening or clipping also plays an important role in the separation of a word into syllables. He proves his syllabification principle that "subject to certain conditions, consonants are syllabified with the more strongly stressed of two flanking syllables" by stating that for example "both the /n/ and the /t/ of *enter* /'ent.ə/ [have to] belong to the first syllable, since the /t/ triggers clipping of both the /e/ and the /n/" (Wells, *Syllabification* 80). Given that the following consonant undoubtedly influences the duration of the preceding vowel, he finds it logical that the consonant which triggers this shortening has to be part of the same syllable as the vowel. The same situation occurs in the word *happy* /'hæp.ɪ/ where the consonant /p/ "belongs to the first syllable, as evidenced by its relative lack of aspiration and by the pre-fortis clipping of the /æ/" (Wells, *Syllabification* 80).

However, the influence of fortis consonants is operational only within morphemes[13]. It is stopped by morphemic boundaries. "When the two elements appear across "morpheme boundaries such as those between the elements of a compound", the consonant remains in the initial position of the second syllable. Wells suggests as an example the compound adjective *high-faluting* where the consonant /f/ belongs to the second syllable, so that there is no pre-fortis clipping of the closing diphthong /aɪ/, as distinct from the noun *hyphen* /'haɪf.ən/ where the /f/ belongs to the same syllable and thus triggers the shortening of the diphthong /aɪ/. As a result, Wells states that the previous principle applies only to monomorphemic words, "in polymorphemic words, consonants belong to the syllable appropriate to the morpheme of which they form a part" and thus they do not trigger pre-fortis clipping (Wells, *Syllabification* 83).

Even though Wells' theory of syllabification seems to have a solid basis, it has to be kept in mind that it is only one of the possibilities of syllabification, not an only one.

Pre-fortis shortening in Czech

Following Chen's statement that pre-fortis shortening is a language-universal phenomenon (139), it is assumed that Czech vowels should behave correspondingly to the other languages, especially Russian with the ratio lying in the 0.8-0.9 region. However, in Czech, this tendency was studied very little (Machač and Skarnitzl 2007, Podlipský and Chládková 2007). Machač and Skarnitzl pointed out that in Czech "the vowel is shorter before a voiceless (longer) plosive than before a voiced (shorter) plosive" ("Compensation" 539) and that it does not apply to all places of articulation. Moreover, they measured that "compensation tendencies appear to be stronger in CV [14] than in VC sequences" ("Compensation" 540), however, their study included both heterosyllabic and tautosyllabic vowel-consonant sequences and they did not indicate the proportion between the two.

Podlipský and Chládková followed up their research but they focused only on tautosyllabic VC sequences in three Czech words with the syllable structure CVC.CV. These words differed in the coda of the first syllable: one word had a voiceless coda, one a voiced coda and one word had a devoiced coda due to its assimilation with the following segment. Nevertheless, it is not possible to find such a minimal set in Czech and thus they chose a

[13] Morpheme is "the smallest meaningful unit in words" (Ogden 176).

[14] C stands for a consonant, V stands for a vowel.

non-minimal set *kapky, babky, ragby* where the coda varied in the desired way but there also existed some differences mainly in the initial consonants that might have modified the results.

They found a significant difference in the duration of the vowel /a/ in these words; however, it is likely that a part of the effect was due to the undesired differences between the words such as the positive VOT of [k] etc. To eliminate these irrelevant variations, Podlipský and Chládková also studied a minimal set of three nonsense words *tapka, tabka* and *tabga*. The durational differences of the vowel /a/ in the second test were not as significant as in the non-minimal real-words set, however, the main effect was still visible (Podlipský and Chládková 69).

As a result, they concluded that "in Czech a vowel is relatively short when followed by a voiceless obstruent, longer when followed by a devoiced […] obstruent and even longer when followed by a voiced obstruent" (70). In other words, the vowel /a/ was the longest in the word *ragby*, shorter when followed by devoiced /b/ in the word *babky* and the shortest in the word *kapky* before a voiceless consonant. Nevertheless, it cannot be ruled out that the difference in vowel duration was observed partly because the words were nonsensical and speakers did not treat them naturally (Podlipský and Chládková 70).

2.1.2.2 Manner of articulation of the following segment

Not only is vowel duration influenced by the voiced or voiceless character of the following consonant, phoneticians have pointed out that the manner of articulation of the adjacent segment also plays an important role (Lehiste and Peterson 1960).

According to their manner of articulation, English consonants are divided into five groups: plosives (stops) /p, b, t, d, k, g/, fricatives /f, v, s, z, ð, θ, ʃ, ʒ, h/, affricates /tʃ, dʒ/, nasals /m, n, ŋ/ and approximants /r, j, w, l/. Plosives, fricatives and affricates are classified as obstruents because they are produced with complete obstruction to the airstream which causes friction (Cruttenden 161). On the contrary, nasals, approximants and also vowels belong to the category of sonorants as they are created with "only a partial closure or an unimpeded oral or nasal escape of air" (Cruttenden 161).

Lehiste and Peterson compared the duration of vowels followed by voiced/voiceless plosives and fricatives and they measured the average durations of vowels as follows: 184 ms before a voiceless plosive, 228 ms before a voiceless fricative, 280 ms before a voiced plosive, and

376 ms before a voiced fricative. The voiced fricatives appeared to have a further lengthening effect than both voiced and voiceless stops. Vowels followed by a plosive came out as the shortest. Affricates and nasals affected the vowel duration in the same way as plosives (Lehiste and Peterson 702). Their results were replicated in 1992 by van Santen. In his experiment voiced fricatives produced also longer durations than voiced stops, and voiceless fricatives longer durations than voiceless stops (van Santen 527). Wiik came to the same conclusion as the other authors. Moreover, he also measured that the "lengthening effect of fricatives is about 15% to 21%" (Wiik 118).

From all the studies presented above, voiced fricatives came out as the most influential on the vowel duration changes, followed by voiced plosives, voiceless fricatives and voiceless plosives. The average durations of English short and long vowels in various environments are depicted in Table 3 and 4.

Vowel	**Before voiced C**		**Before voiceless C**	
	C=fricative	C=plosive	C=fricative	C=plosive
ɪ	186	147	83	73
e	178	163	113	100
ʌ	188	168	105	96
ʊ	180	143	133	88
ə	188	179	125	107
æ	252	216	165	150

Table 3. Duration of short vowels in milliseconds, originally in centiseconds, C stands for a consonant (adapted from Wiik 114).

Vowel	**Word finally**	**Before voiced C**		**Before voiceless C**	
		C=fricative	C=plosive	C=fricative	C=plosive
i:	280	360	285	130	123
ɜ:	265	370	282	185	164
u:	307	307	282	131	110
ɔ:	339	390	324	212	172
ɑ:	340	351	299	227	197

Table 4. Duration of long vowels in milliseconds, originally in centiseconds, C stands for a consonant (adapted from Wiik 114).

2.1.2.3 Place of articulation of the following segment

Another important factor with some impact on vowel duration is the place of articulation of the adjacent consonant. In terms of their place of articulation, English consonants can be: bilabial (/p, b, m/), labiodental (/f, v/), dental (/ð, θ/), alveolar (/t, d, n, s, z, l/), post-alveolar (/r/), palato-alveolar (/ʃ, ʒ, ʧ, ʤ/), palatal (/j/), velar (/k, g, ŋ/), labio-velar (/w/) and glottal (/h/) (Cruttenden 161). Their classification can be seen in Table 5.

Crystal and House measured that vowels were longer when they were followed by labial or alveolar consonants than when followed by velar consonants (1578). However, neither van Santen, nor Luce and Charles-Luce repeated their results. Luce and Charles-Luce found the durations of vowels before bilabial plosives to be only 8 ms longer before alveolar plosives and 9 ms longer before velar plosives. According to their results, vowels before bilabial stops were 155 ms long, before alveolar stops 147 ms and before velar stops only 146 ms long (Luce and Charles-Luce 1951). Van Santen came to contradictory results with those presented by Crystal and House. In his set of data, the vowels followed by velar /ŋ/ or /g/ were longer than those followed by bilabial /m/ or /b/ (van Santen 528). As a result, it is not clear whether the place of articulation of the following consonant in Crystal and House's experiment has really any influence on the preceding vowel duration or whether it was only a consequence of the ignored factor of syllabic stress or mode of speaking.

	Plosive	**Fricative**	**Affricate**	**Nasal**	**Approximant**
Bilabial	p, b			m	
Labiodental		f, v			
Dental		θ, ð			
Alveolar	t, d	s, z		n	l
Post-alveolar					r
Palato-alveolar		ʃ, ʒ	ʧ, ʤ		
Palatal					j
Velar	k, g			ŋ	
Labio-velar					w
Glottal		h			

Table 5. The classification of English consonants based on their manner and place of articulation (adapted from Cruttenden 161).

2.1.3 Vowel position within a syllable

Vowel duration in English is also influenced by the position of the vocalic element within a syllable and by the presence or absence of stress. A vowel is said to be longer when occurring in a stressed syllable than the same vowel in an unstressed position. Klatt pointed out that "the average (median) duration for a stressed vowel is about 130 ms" whereas "the average duration for unstressed vowels, including schwa, is about 70 ms" (1209). He also mentioned that "the difference is largest in a phrase-final syllable, where an unstressed vowel is about 65% of the duration that it would have if stressed" (1213).

Subsequently, in 1988 Crystal and House examined the influence of stress on vowels in diverse contexts. Their results indicate that vowels in stressed syllables are twice as long as the same vowels in unstressed positions. Afterwards, in 1992, the results of van Santen showed that the difference between the duration of English vowels in stressed and unstressed syllables is 70 ms on average. His results are in agreement with those presented by Crystal and House in 1988.

Van Santen also studied vowel duration in primary and secondary-stressed syllables. He found out that the difference between the duration of vowels under primary and secondary stress was approximately 50 ms. His results are depicted in Table 6.

Segment	**Unstressed**	**Primary stress**	**Secondary stress**
ə	68	-	-
ɪ	74	90	96
ʊ	87	104	92
ʌ	77	116	123
ɛ	89	118	110
i	101	137	121
u	105	136	-
ɚ	98	154	140
eʲ	139	162	147
o	142	162	145
ɑ	151	176	168
aʲ	172	171	186
æ	148	173	161
ɔ	-	189	-
aʷ	-	203	-
ɔʲ	-	222	-

Table 6. Raw vowel durations in milliseconds for American vowels in utterance-medial positions in accented words (adapted from van Santen 523).

Moreover, he pointed out that "while the effect of stress for syllables in deaccented words was less than for syllables in accented words, it certainly was not zero" (543). As a result, he concluded that "stressed syllables [do not] become durationally distinct only in accented words" (543).

2.1.4 Location of the word within a sentence

Another factor with the influence on vowel duration is the position of the word within a sentence, especially when dealing with words closer to word boundaries. It is generally known that vowels in utterance-final words are lengthened due to the phenomenon called prepausal lengthening or final deceleration. In Czech, this tendency was studied recently by Volín and Skarnitzl in read speech. In their experiment, they came to the conclusion that there is a "short deceleration at the beginning of the phrase, moderate deceleration or level tempo in the middle, and quite substantial deceleration at the end" (Volín and Skarnitzl 444).

This tendency has also been studied in connection with vowel duration. Luce and Charles-Luce found "vowel durations longer for test words produced in phrase-final than in nonphrase-final positions" (1951). Their results indicate that vowel durations were approximately 69 ms longer in phrase-final than in non-phrase final positions (Luce and Charles-Luce 1951). Moreover, Klatt pointed out that "the syllable before the pause increases by about 60-200 ms, with most of the durational increment restricted to the vowel and any postvocalic sonorant or fricative consonant" (1211).

Nevertheless, in 1992, the results of Van Santen demonstrated that "utterance-final lengthening is not confined to the final syllable of an utterance" (536) since his results also showed 11% lengthening for vowels in utterance-penultimate syllables and 5% prolongation of vowels in the first syllable in three-syllable words (536).

Even though prepausal lengthening is a well-known phenomenon, the reason for the deceleration at the end of an utterance is yet to be discovered. Klatt suggests two possible reasons: either "the speaker learns to lengthen segments at the ends of phrase boundaries in order to help the listener decode the message", or there is "a natural tendency to slow down at the ends of all motor sequences or planning units" (1212). He is inclined to think that it is more likely to be caused by the natural "deceleration of motor activity at the ends of speaking acts" (Klatt 1212).

2.1.5 Length of the word

The length of the word containing the studied vowel also has an influence on its duration. Wiik found out that "the duration of primary-stressed [vowels] is longer in monosyllabic words than in words in which unstressed [vowels] follow the primary stressed one" (119). He measured the length of vowels in pairs of words such as mean-meaner, ham-hammer which contain the same vowel followed by the identical consonant, the only difference was that the first word was monosyllabic and the second word disyllabic. He assessed the lengthening effect to 65% (Wiik 119). He also stated that "in disyllabic words the duration of the primary-stressed [vowel] is not so much affected by the voicing of the following [consonant] as it is in monosyllabic words" (Wiik 119).

This factor was also studied by a Czech student Fejlová in her bachelor thesis at the Institute of Phonetics, Faculty of Art, Charles University and her later article based on the results of her thesis. She compared the extent to which pre-fortis shortening is employed by native speakers and Czech students of English in connected speech in polysyllabic words. Her objective was to compare the degree of employment of pre-fortis shortening with the strength of foreign accent in Czech English. In Fejlová's experiment, the studied words were not pronounced in isolation, they were extracted from meaningful texts. As a result, they were also polysyllabic and occurred in various prosodic positions (Fejlová 95). Her results indicate that "the difference in the duration of pre-fortis and pre-lenis vowels is considerably lower in connected speech than in previously reported results, even in native speakers" (91).

As expected, mean vowel durations were most similar in category containing students with the strongest Czech accent (0.85 ratio) (Fejlová 96). Unexpectedly, "category B (less strong accent) speakers yielded a lower duration ratio (0.81) than speakers in the native-like category (0.83)" (Fejlová 96). However, this discrepancy was later explained by the extremely good results of one student in category B. Her results prove the belief that "pre-fortis shortening is hard to detect in fluent speech" since "the differences in vowel durations before fortis and lenis consonants […] are somewhat blurred in communicative contexts, even for native speakers" (Fejlová 97).

2.2 Function of vowel duration in English vs. in Czech

It is widely acknowledged that vowels in both Czech and English are realised with varying duration. Vowel duration is a significant attribute of both languages, however, in each of them, it has different functions.

The main distinction is that in Czech vowel duration has a contrastive function (Palková 191, as translated and paraphrased by Helena Hrychová). Czech long vowels are almost twice as long as the short ones, the ratio of long/short vowels is considered to be 2:1 and thus Czech native speakers are able to contrast the meaning of a word only on the ground of different duration of vowels that do not show qualitative differences, e.g. *pas* (passport) vs. *pás* (belt) (Palková 179, as translated and paraphrased by Helena Hrychová). However, according to the perception tests by Janata and Jančák from 1970, the evaluation of the difference in vowel duration in Czech also depends on various factors. In words with a vowel located in the final position, longer vowel duration is necessary for the categorization of the vowel as long when compared to the CVC[15] type (consonant located finally), where shorter duration suffices. Moreover, a difference between two concrete words emerged which indicated the dependence on not just phonetic factors (Janata and Jančák 1970 in Palková 179, as translated and paraphrased by Helena Hrychová). However, Czech vowel duration is not influenced by the placement of stress since the stress in Czech is fixed on the first syllable of the word (Palková 157, as translated and paraphrased by Helena Hrychová).

In addition, Czech vowel duration does not serve as a cue to the perception of the voicing characteristic of the following consonant since both the voicelessness and voicedness is passed across word boundaries due to the assimilation process. The final voiced consonant can become fully voiceless when followed by an initial voiceless consonant in the following word, for example the /z/ in the sequence *vůz popojel* becomes voiceless /s/ [vu:s popojel]. The same regressive assimilation of voice occurs when a final voiceless consonant is followed by a voiced consonant in the initial position of the following word such as the voiceless /t/ followed by voiced /z/ in the sequence *výlet začal* where voiceless /t/ becomes voiced /d/ [vi:led začal]. The assimilation of voice occurs in Czech also within the words. For example when a voiced consonant is followed immediately by a voiceless consonant such as in the word *výpravčí* [vi:prafči:], the originally voiced /v/ becomes voiceless /f/ (Cvrček et al. 51, as translated and paraphrased by Helena Hrychová).

[15] C stands for a consonant, V stands for a vowel.

On the contrary, this assimilation principle does not appear in English where even when a final consonant becomes devoiced such as the final voiced /g/ in the word *dog*, it still maintains its lenis character, it does not become voiceless /k/ and therefore, the following devoiced consonant is recognized according to the length of the preceding vowel.

The functions of English vowel duration were also studied by numerous perception experiments. Lawrence Raphael studied the function of vowel duration in American English as a cue to the perception of the voicing characteristic of word-final consonants. He found out that listeners tended to perceive the final consonants as voiceless when they were preceded by shorter vowels and as voiced when they followed the vowels of longer duration. (Raphael, "Perception" 1296). Raphael also discovered that "the cue of preceding vowel duration is more effective before stops than before fricatives" (Raphael, "Perception" 1301).

That is exactly the substantial problem difficult to grasp for Czech students. They do not pronounce English vowels with adequate duration which can cause misunderstanding. For instance, the word *ice*, if not pronounced with the correct vowel duration before the fortis fricative, can be mistaken for the word *eyes* in the sentence: *I think there is a fly in my ice*. Moreover, the final plosive might also be misidentified such as in the sentence: *Where is the dog?*, where the voiced /g/ becomes devoiced in the final position but it still retains its lenis character and therefore should not trigger pre-fortis shortening. As a result, the vowel duration of /ɒ/ should still be longer than in the word *dock*.

To conclude, we have seen how complex English vowel duration is and how many factors have to be taken into consideration while examining vowel quantities. Let us now focus on the empirical part of this thesis and put all the various factors which influence vowel duration into practice.

EMPIRICAL PART

The empirical part of this thesis focuses on pre-fortis shortening in the speech of Czech users of English. The aim was to find out whether they make use of this feature at all and how it correlates with their proficiency in English. Based on the research findings on vowel duration summarised in the theoretical part and inspired by the research study conducted in Czech English, the following hypothesis was formulated:

Advanced Czech students of English will exploit pre-fortis shortening to a larger extent than those with a lower language level.

For this reason, we decided to measure vowel durations of Czech students to ascertain whether they produce selected English vowels with adequate durations and also how it correlates with their proficiency in English.

3 Method

In order to confirm or refute the given hypothesis, an experiment was conducted with an objective to compare the durations of vowels of 20 Czech students at two different language levels.

Firstly, a set of suitable short sentences for recording was created and Czech students were recorded while reading it. Secondly, their recordings were analysed and the target words underwent the process of segmentation. Finally, the vowel durations in several environments were compared with each other and the measured differences were statistically evaluated.

3.1 Sentences for recording

First of all, it was indispensable to create a text for recording containing several minimal pairs of words differing only in the voicing of the final consonant. The words were not recorded in isolation to enable the examination of the studied words in connected speech and to ensure a more natural discourse of the participants. However, the words still do not serve as an example of natural discourse since they were studied in read sentences and not in a spontaneous speech.

The placement of the target words within the sentences had to follow a number of rules:

1. The words were not located at the end of the sentence to avoid the unintentional consequences on vowel duration caused by the phenomenon known as prepausal lengthening (see 2.1.4).
2. They were all situated in a stressed position apart from the possessive pronoun *his* (see 2.1.3).
3. The words did not appear in a position followed by a vowel to eliminate the effect of consonant-to-vowel linking devices.

A total of 40 sentences comprising 21 minimal pairs and one pair differing not only in the voicing of the final consonant but also in the quality of the preceding vowel in the pair *foot* /fʊt/ - *food* /fu:d/ was selected.

The length of both short and long vowels and diphthongs was studied in various environments: followed by a voiced/voiceless plosive, fricative or affricate. The short vowel /ə/, long vowels /ɜ:, ɑ:, ɔ:/ and diphthongs /ɔɪ, aʊ, ɪə, ʊə, eə/ were excluded from the study.

The selected minimal pairs can be seen in Table 7, for the whole set of sentences used for recording see Appendix 1.

Voiceless member of the minimal pair	**Voiced member of the minimal pair**	**Voiceless member of the minimal pair**	**Voiced member of the minimal pair**
duff	dove	broke	brogue
cup	cub	safe	save
foot	food	bus	buzz
etch	edge	rice	rise
back	bag	batch	badge
rich	ridge	height	hide
dock	dog	rope	robe
mop	mob	bet	bed
lit	lid	loose	lose
leak	league	leaf	leave
late	laid	his	hiss

Table 7. A complete set of 22 minimal pairs selected for recording.

3.2 Questionnaire

Secondly, a questionnaire for the respondents was created. The questionnaire did not mention the name of the topic examined in the experiment so that the results would not be affected by the respondents' knowledge of the studied phenomenon.

Altogether, it contained six questions concerning the age and gender of the respondents, their level of English (length of their English studies), recent regular contact with a native speaker, long-term stay in an English-speaking country and the frequency of watching series or films in original version. The questions were in majority closed-ended with a few usually additional open-ended questions. The respondents were asked to circle the correct answer or to write their own. The questionnaire was strictly anonymous. For later identification, it was only numbered according to the number of the student's recording[16]. The questionnaire in Czech can be seen in Appendix 2.

3.3 Respondents

A total of twenty Czech students from two age groups and two native speakers participated in the experiment. The first group included 10 third-year university students from the Department of English Language and Literature, Faculty of Education, Charles University; more specifically 8 women and 2 men aged 21 to 23 with an approximate English level C1. According to their answers in the questionnaire, they have been studying English for approximately 13.5 years. They all attended a one-year course of English Phonetics and Phonology where they were familiarised with the pre-fortis shortening phenomenon. Four of them were lately in regular contact with a native speaker and all of them regularly watched British or American TV series and films in their original version (3 of them daily, 3 of them several times a week, 3 of them once a week and 1 once a month). Only two of them (C1_004 and C1_006) spent a longer period of time in an English-speaking country. The respondent C1_004 spent 10 months in Wisconsin, USA and the respondent C1_006 visited Canada twice for 3 months during the last two summer holidays.

The second group consisted of 10 higher secondary school students (6 boys, 4 girls) aged 14 to 16 from Gymnázium J. Gutha-Jarkovského, Prague with an approximate level A2.

[16] Initially, the recordings were numbered 1-10 for the C1 level group and 21-30 for the A2 level group, however, for easier identification they were later renamed according to the level group to either A2_001 – A2_010 or C1_001 – C1_010.

They have been studying English for 9.4 years on the average. They did not attend any course specialised in phonetics. Even though none of them spent a longer period of time abroad, 9 of them were watching British or American TV series and films regularly in their original version (2 several times a week, 6 once a week and 1 once a month) and 3 of them were lately in regular contact with a native speaker (1 twice a week, 1 once a week and 1 once a month).

In addition, two female native speakers also participated in the experiment, one 30-year-old teacher from Lincolnshire, UK and one 19-year-old university student from Utah, USA.

3.4 The process of recording

The recording of the Czech students took place in an empty room, however, not all the noises were eliminated since the room was not sound-proof. A digital voice recorder Edirol R-09 HR ver. 2.0 was used for recording. The students were recorded individually so as to reduce the noise in the room and also the nervousness of the respondents.

Firstly, the participants were given a questionnaire written in Czech and they had unlimited time to complete it truthfully.

Secondly, a short conversation in English was held between the students and the supervisor so as to allow them to get tuned into the English language and to be prepared for reading in English. They were asked simple questions such as: What kind of series do you usually watch? Have you ever been to an English-speaking country?

Thirdly, they were given the first column with 20 sentences, which contained the first set of minimal pairs, and they were instructed to read it silently. The order of the sentences was randomised (see Appendix 1). They were allowed to ask the supervisor about the pronunciation of the unknown words. In addition, the pronunciation of the vowels in the minimal pair *duff-dove* was already written above the words so as to avoid the incorrect pronunciation of *dove* as /dəʊv/* etc.

After they had familiarised themselves with the sentences, they were given the instructions on how to read them. They were asked to read in a relaxed manner and as fluently as possible, to be approximately 10 cm from the microphone and to read the whole sentence once again if they made a mistake. However, the last instruction was not properly followed by all participants. Several students were asked to re-read some of the

sentences after they had finished the lecture of a sentence or a whole column. Despite all these precautions, certain mistakes were not prevented.

Lastly, the students were given the second set of 20 sentences containing the second item of the minimal pair and they had again unlimited time to prepare themselves and to ask the supervisor further questions. Afterwards, they were recorded while reading all the sentences in succession.

As far as the native speakers were concerned, they were not recorded in person, they were sent the sentences for recording by e-mail with the same instructions as the Czech students. They did not use a professional recorder and therefore, the quality of their recordings is not as high as of those obtained with Edirol R-09 HR digital voice recorder, however, they turned out to be sufficient for the subsequent analysis.

3.5 Analysis of the recordings

When all the recordings had been obtained, the data analysis in the Praat programme began (Boersma and Weenink). For each recording, a TextGrid (Praat label file) was created containing three tiers - phone, word and sentence.

First of all, the sentences were manually labelled by the author of the study in the Praat software. For the sentences which were read by the students several times, only one of these variants was selected, either the better pronounced one, or the one containing the target word in higher quality.

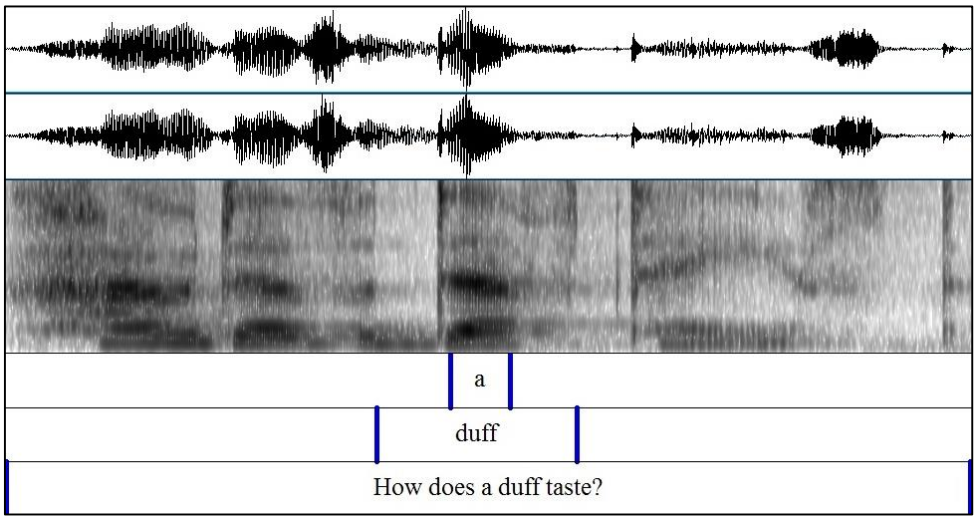

Figure 5. Example of labelling process in the Praat programme (Boersma and Weenink). The figure symbolizes the segmentation of a sentence *How does a duff taste?* which is represented by a waveform, a spectrogram and three tiers indicating the three levels of segmentation: phone, word and sentence.

Secondly, the studied words were manually labelled according to the segmentation rules listed in Machač and Skarnitzl (2009). The target vowels were labelled following the same rules as for the words. When it was not evident where exactly the vowel started or ended, the boundary was placed in the middle of the transition area. For the minimal pair *etch-edge* where the vowel was located initially, the existence of a glottal stop (ʔ) had to be taken into account. It was labelled separately and it was not included in the overall vowel duration (see Figure 6).

The various glottal stops inserted by the British native speaker before tautosyllabic voiceless plosives were also not counted as a part of the target vowel as well as the aspiration accompanying voiceless plosives /p, t, k/.

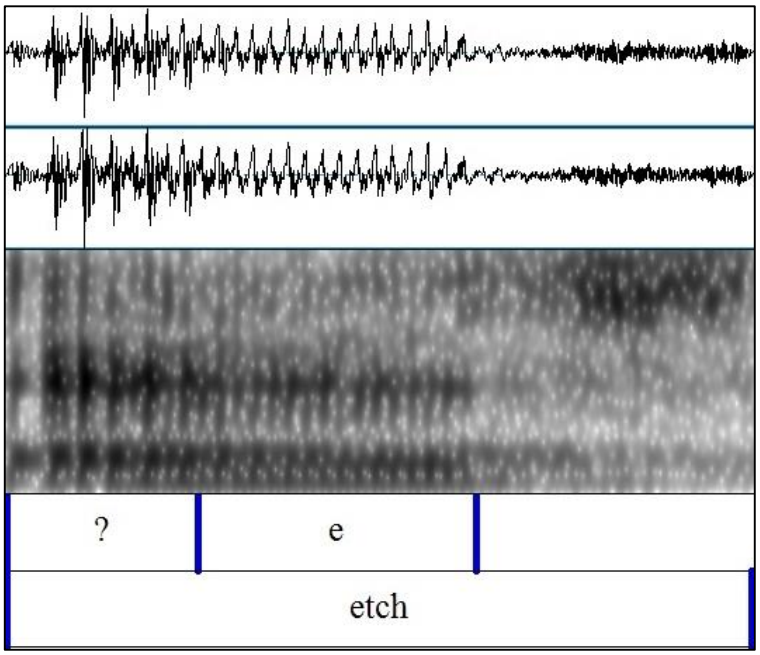

Figure 6. Segmentation of the word *etch* realized with a glottal stop.

A total of 880 vowel tokens from the Czech speakers of English and 88 tokens from the native speakers was analysed. The number of vowels in pre-fortis contexts was the same as the number of vowels in pre-lenis contexts.

After the segmentation process had been completed, all the necessary data were then extracted from the material with the help of a Praat script which picked out only the duration of the target vowel. Then, the data were copied to MS Office Excel 2013 and inserted into a table containing six columns: speaker, word, vowel, voicing/voicelessness of the following consonant, its manner of articulation and the obtained vowel duration.

Subsequently, in order to reduce the effect of speech rate on vowel duration, the given durations had to be normalised against individual speech rate to eliminate the unwanted differences in duration caused by the varying speech rate of the students. For all 22 respondents, the sentence number 16 was selected for normalisation. It was necessary to choose one sentence approximately in the middle of the whole set, however, since two sets of questions were recorded separately, the sentence from the final section of part I was chosen because the sentences in the final part of part II would not be suitable for normalisation since the respondents tended to speed up before the end. The sentences from both initial sections proved to be also inconvenient, since they did not seem to correspond to the average speech rate.

First of all, the individual speech rate was calculated as the number of sounds in the selected sentence divided by the duration of the whole sentence for the individual speaker. Afterwards, an average speech rate was calculated as the average of all the individual speech rates. The coefficient for normalisation was then calculated as the quotient of the individual speech rate and the average speech rate. Subsequently, vowel durations for all speakers were multiplied by the coefficient which created the normalised duration. From now on, the term duration will refer only to the normalised duration.

Finally, several t-tests were used to determine whether the measured difference between the two sets of data was statistically significant or not. For each set, the p-value (probability value) or the "estimated probability of rejecting the null hypothesis" was calculated (Buchan). The null hypothesis was defined as a hypothesis of no difference between the two sets of data. According to the acquired p-value, the results were marked to be either statistically highly significant ($p<0.001$), statistically significant ($p<0.05$) or not significant ($p>0.05$) (Buchan).

4 Results

First of all, it should be noted that only normalised vowel durations were examined in this experiment since they give more accurate information about the effect of pre-fortis shortening. It was expected that the students with the A2 level would speak more slowly and therefore their vowel durations would not be comparable to the more advanced students. Thus, normalisation process was convenient since it eliminated the influence of speech rate on vowel duration.

We focused mainly on the relation between the speakers' proficiency in English and their vowel durations, however, also some other factors mentioned in the theoretical part were examined: the influence of the voicing of the following consonant, its manner and place of articulation and the inherent characteristics of the vowels.

4.1 The influence of the voicing of the following consonant

The result of the first overall analysis served as a confirmation of the fact that vowels in Czech English also tend to be longer when followed by voiced as opposed to voiceless consonants. Chart 1 indicates that with both language levels combined, vowel duration before lenis consonants is greater than before their fortis counterparts with the average difference 7.7 ms. The difference turned out to be highly statistically significant ($p < 0.001$).

The ratio of vowel durations before fortis/lenis consonants averages 0.93 which is more than the ratio provided by Chen (0.61). However, it can be assumed that this difference was caused by the fact that Chen's ratio was measured for English native speakers and thus Czech English was likely to evince the influence of the mother tongue and therefore Czech accent.

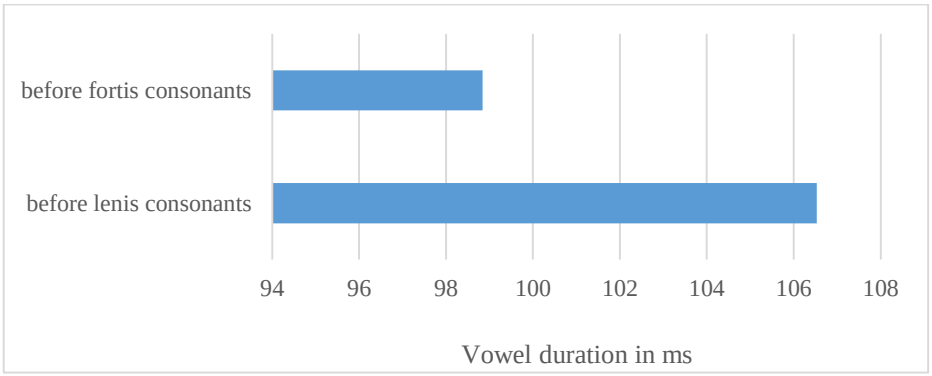

Chart 1. Average duration of English vowels before fortis/lenis consonant regardless of the language level of the respondents.

Subsequently, the average vowel durations before fortis and lenis consonants were compared for the two levels of English (A2/C1) and native speakers to examine how the degree of vowel duration correlates with the speaker's proficiency in English. Chart 2 shows that the average durations of vowels before fortis/lenis consonants for the two levels do not differ as significantly as expected. The difference in the duration of vowels followed by lenis consonants between the A2 and C1 category amounts to 12.4 ms and for vowels followed by fortis consonants only to 6.9 ms.

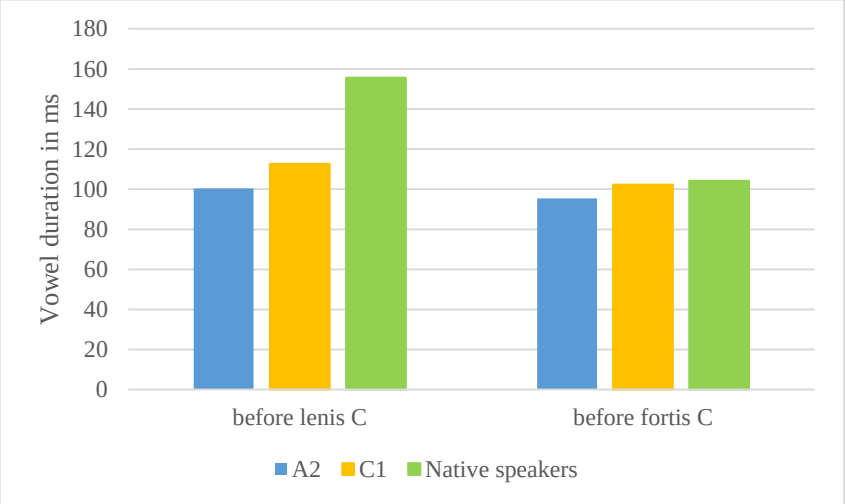

Chart 2. Average duration of vowels before fortis/lenis consonants for respondents at A2, C1 level and native speakers, C stands for a consonant.

Moreover, in comparison with the results obtained for the native speakers, it seems that vowel durations before fortis consonants are almost even for all the three categories, however, in the category of vowels followed by lenis consonants, native speakers produced vowels 42.8 ms longer than the students with the C1 level and 55.3 ms longer than the students from the A2 group.

Taking into consideration the results of the t-tests, the difference between vowels before fortis and lenis consonants was the highest in the category of native speakers (51.5 ms) which was proven to be statistically highly significant ($p<0.001$). The difference measured for the C1 category was considerably lower (10.4 ms), however, it was still ascertained as statistically highly significant ($p<0.001$). On the other hand, the results obtained for the A2 category showed only a negligible difference in the duration of vowels before fortis and lenis consonants (4.9 ms) which was not proven to be statistically significant ($p>0.05$).

Furthermore, for vowels followed by voiced consonants the p-value proved the difference between the A2 and C1 category as statistically highly significant ($p<0.001$). For the variance in the duration of vowels before voiceless consonants for the two categories the p-value was slightly higher, however, the difference can be still considered statistically significant ($p<0.05$).

The duration of vowels followed by either fortis or lenis consonants was also examined with respect to the forth question in the questionnaire regarding the students' long-term stay in an English-speaking country. Since only two students from the C1 category (C1_004 and C1_006) spent more than a month abroad, these two students were compared to the rest of the students from the C1 level group. Even though the difference between the durations of vowels followed by fortis consonants in the two categories was only 0.41 ms, the difference between the durations of vowels followed by lenis consonants (5.09 ms) indicates that there probably is a relation between vowel duration and a long-term stay in an English-speaking country which manifests itself on vowel durations before lenis obstruents. However, we have to bear in mind that only the duration of two students was examined which does not allow further generalization of the results.

The results of the two students manifested 14.8 ms difference in the duration of vowels before fortis and lenis consonants which was ascertained by a t-test to be a statistically significant difference ($p<0.05$). In addition, the difference between the durations before voiced/voiceless consonants for the rest of the C1 category (9.3 ms) proved to be also statistically significant ($p<0.05$).

Vowel durations for the two students compared to the rest of the C1 category can be seen in Chart 3.

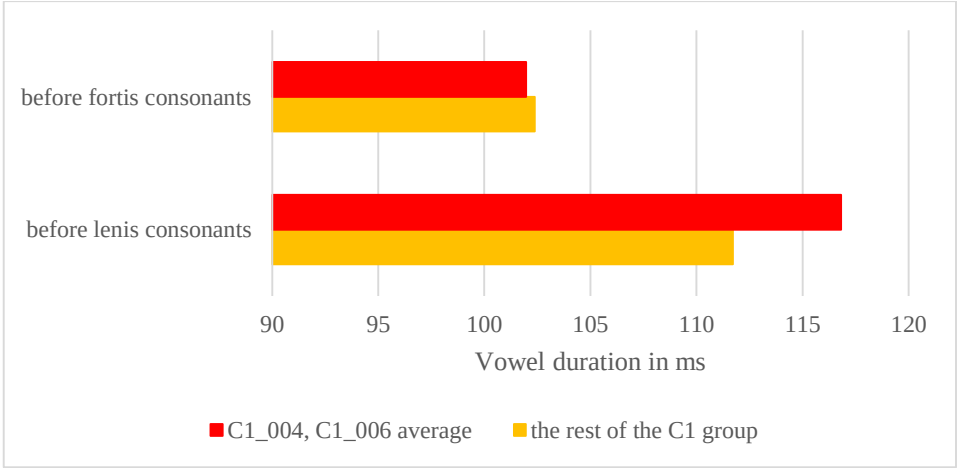

Chart 3. Relation between vowel duration and a long-term stay in an English-speaking country.

Nevertheless, it has to be mentioned that vowel durations were not examined with respect to other questions from the questionnaire since the answers were similar for all the participants and they did not prove to be of great importance on vowel duration differences.

4.2 Duration of lax/tense vowels and diphthongs in the fortis/lenis environment

Subsequently, the influence of the fortis/lenis environment on the preceding vowel duration was studied separately for the three categories of English vowels: lax and tense vowels and diphthongs. The differences in the duration of all vowels in both fortis or lenis environments were not as significant as expected. The difference between the duration of lax vowels followed by lenis and fortis consonants in the A2 category was only 3 ms, which was not ascertained to be statistically significant ($p>0.05$). The same difference obtained for the C1 category was approximately 13 ms and for the category of native speakers even 56 ms. For the C1 category, the results were ascertained to be statistically significant ($p<0.05$) and for the category of native speakers even statistically highly significant ($p<0.001$).

The examination of tense vowels in fortis/lenis environment showed even more surprising results. Even though the vowel durations before lenis consonants in the A2 category were 5 ms longer than those obtained for the fortis environment and in the category of native speakers even 63 ms longer, the results for the level C1 are startling. The durations of tense vowels before fortis consonants came out almost the same as those measured for the lenis environment which indicates that the measured overall difference of vowel durations before fortis and lenis consonants for the level C1 must have been caused only by the shortening of lax vowels. However, from the measured differences of the duration of tense vowels before either fortis or lenis consonants, only the results obtained for the category of native speakers were proven to be statistically significant ($p<0.05$), the results of both A2 and C2 category were not ascertained as statistically significant ($p>0.05$).

When compared to the category of tense vowels, diphthongs did not provide any astounding results. The diphthongs followed by fortis consonants were 5 ms shorter in the A2 category and 10 ms shorter in the C1 category, however, only the results obtained for the category C1 were ascertained by a t-test as statistically significant ($p<0.05$), the difference in the duration of diphthongs in the A2 category was not significant ($p>0.05$)

and the difference obtained from the native speakers (31 ms) was also not significant ($p>0.05$).

The results for both short/long vowels and diphthongs are presented in Chart 4.

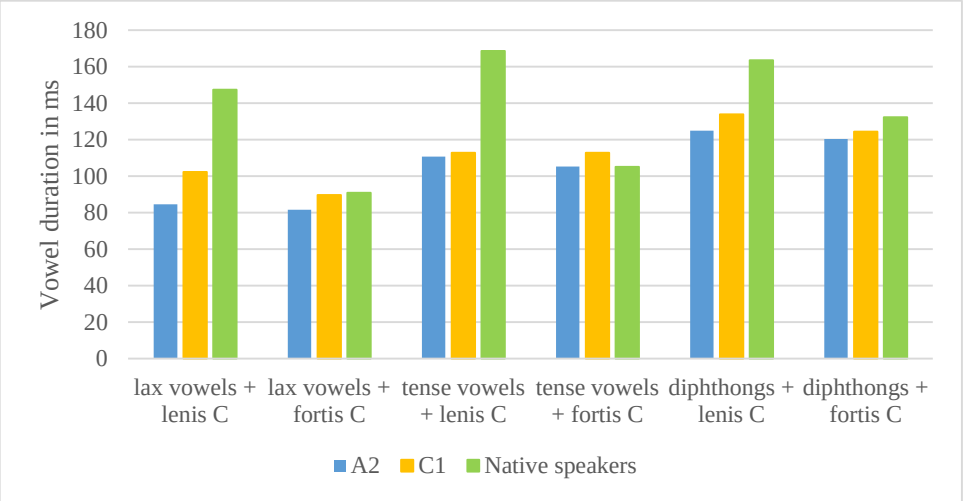

Chart 4. Duration of English lax/tense vowels and diphthongs in fortis and lenis environments, C stands for a consonant.

4.3 The influence of the manner of articulation

Afterwards, the influence of the manner of articulation on variations in vowel duration was investigated. Even though in the experiments stated in the theoretical part the fricatives were considered as the most influential class inducing the greatest lengthening of the preceding vowel, our measurements did not fully prove this theory for Czech students. The vowels followed by a voiceless fricative were a little longer than those before a voiceless plosive (4.4 ms in the A2 category and 3.3 ms in the C1 category), however, the vowels followed by voiced plosives were in both categories longer than those followed by voiced fricatives. Affricates turned out to be the least influential class with the durations of the preceding vowels 75.9 ms (A2) and 94.7 ms (C1) when followed by voiceless affricates and 78.5 ms (A2) and 84.7 ms (C1) when followed by voiced affricates.

However, we cannot draw conclusions only from the measured durations since in both A2 and C1 groups only the differences between fortis and lenis plosives were ascertained to be statistically significant ($p<005$). On the other hand, the results for all three manners of articulation were ascertained to be statistically significant in the category of native speakers where the difference between the durations of vowels followed by a fortis/lenis

plosive was measured to be 51.4 ms, by a fortis/lenis fricative 49.8 ms and by a fortis/lenis affricate even 55.3 ms. The results for all three manners of articulation are depicted in Chart 5.

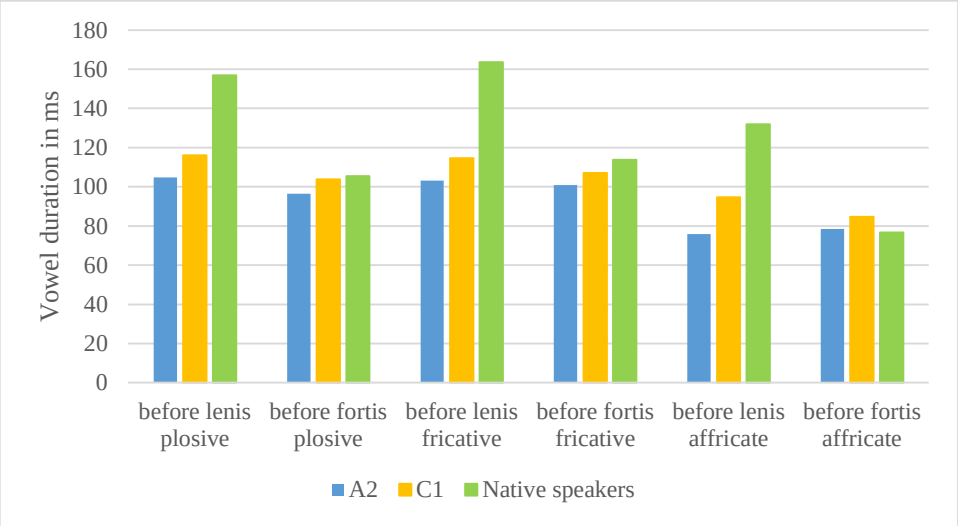

Chart 5. Duration of vowels in six different environments: before a voiced/voiceless plosive, fricative and affricate.

4.4 The influence of the place of articulation

The influence of the place of articulation on vowel duration was also examined in both groups and compared to the results obtained from native speakers.

As far as the categories of A2 level and native speakers were concerned, labiodental consonants were measured to be the most influential class on vowel duration. Vowels followed by lenis labiodental consonants were approximately 115.6 ms long for the C1 category and 176.7 ms long for native speakers. In the C1 category, labiodental consonants did not come out as having the greatest impact on preceding vowel duration, they were surpassed by 8.3 ms by lenis velar consonants. Vowels followed by velar consonants pronounced by students from the C1 category were approximately 129.7 ms long.

Palato-alveolar turned out to be the least influential place of articulation for the C1 level and the native category. Vowels followed by fortis palato-alveolar consonants were 84.7 ms long for the C1 category and 76.7 ms long for the category of native speakers. In the A2 level category, fortis palato-alveolar consonants were the second least influential class, surpassed surprisingly by lenis palato-alveolar consonants. The differences

between the duration of fortis and lenis labio-dental consonants were not ascertained to be statistically significant for the A2 and C1 category ($p>0.05$) and statistically significant for the category of native speakers ($p<0.05$). The differences between the duration of fortis and lenis velar consonants were ascertained to be statistically significant for all the three categories ($p<0.05$).

Taking into consideration the results for the native speakers mentioned in the theoretical part, it seems that our result for the C1 category corresponds to the results obtained by van Santen who measured vowels followed by velar consonants to be longer than those followed by bilabibials (528). On the other hand, the results obtained for the A2 category and the category of native speakers correspond to the results of Crystal and House who found vowels to be longer before labial consonants than before velars (1578). As a result, it is not possible to ascertain whether there is a relation between the place of articulation of the following consonant and the duration of the preceding vowel or whether the results are only coincidental.

The results obtained for vowels followed by voiced/voiceless bilabial, labiodental, alveolar, palato-alveolar and velar consonants are depicted in Chart 6.

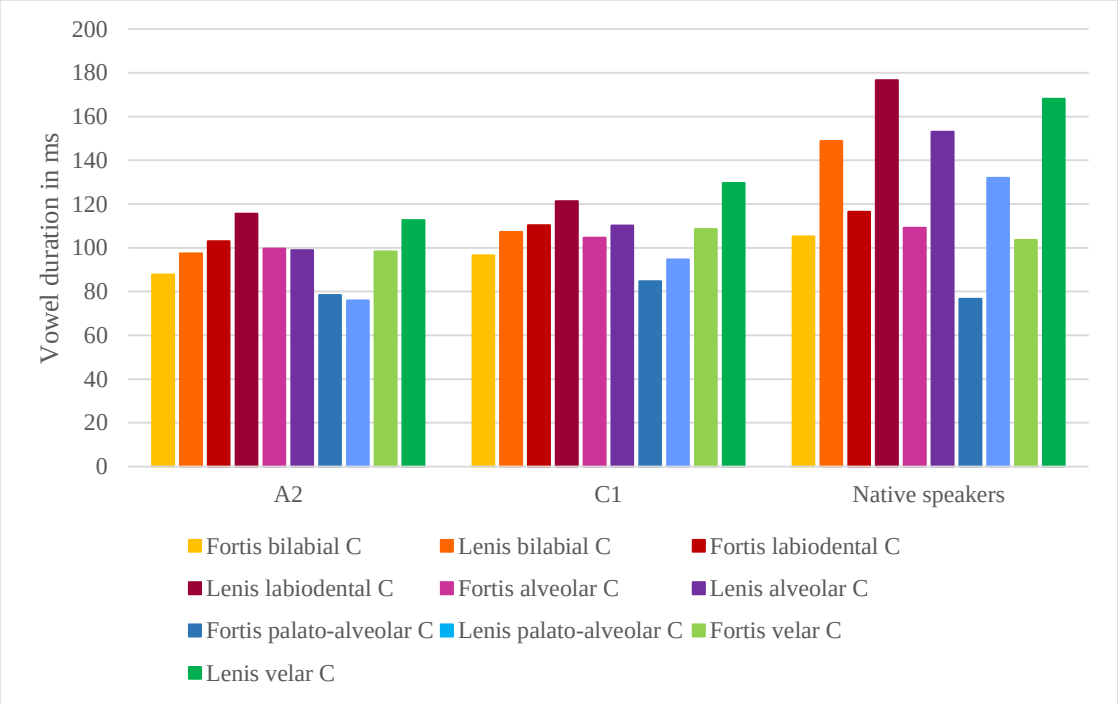

Chart 6. Relation between the duration of vowels and the place of articulation of the following consonant, C stands for a consonant.

5 Discussion

The results presented in the previous chapter indicate that pre-fortis shortening phenomenon occurs also in Czech English. However, the extent to which it is exploited is not as high as in the pronunciation of native speakers. It was discovered that in both A2 and C1 category, the durations of vowels before fortis consonants were comparable to those obtained for native speakers, however the durations of vowels followed by lenis consonants were much longer in the pronunciation of native speakers than in either A2 or C1 level groups. This tendency was probably caused by the fact that Czech students tend to pronounce the final consonants as voiceless because of the assimilation of voice present in Czech and therefore they do not pronounce vowels followed by lenis consonants as longer than those followed by fortis consonants.

To find out whether the results for the lenis category are related to the exposure of the student to English in the native environment, the durations of the two students from the C1 category who spent a longer period of time in an English-speaking country (Canada or the USA) were compared to those obtained from the rest of the C1 group. A significant increase in vowel durations before lenis consonants for the two students indicates that the long-term exposure to English in natural environment can possibly have an impact on vowel duration before lenis consonants. However, it has to be remembered that only a very small number of participants were studied and therefore it is not possible to generalize the results.

Another examination displayed that in Czech English lax vowels are affected by the pre-fortis shortening more than tense vowels and diphthongs which is probably caused by the intrinsic phonological characteristic of tense vowels.

As far as the influence of the manner of articulation was concerned, Czech English vowels were longest when followed by plosives and shortest when followed by affricates which contradicts the results mentioned in the theoretical part where fricatives were measured to be the most influential class on vowel duration changes. However, it has to be kept in mind that the results presented in the theoretical part focused only on the pronunciation of native speakers and therefore, the results obtained for Czech speakers are likely to be influenced by the negative transfer from the mother tongue and thus be different from those obtained from native speakers.

Lastly, the influence of the place of articulation was examined which indicates that vowels in Czech English are longest before lenis velars in the C1 category and before lenis labiodentals in the A2 category. The least influential place of articulation was palato-alveolar in both categories which correlates with the results obtained for the manner of articulation where affricates which have a palato-alveolar place of articulation were also measured to be the least influential class. Nevertheless, the results cannot also be applied to the palato-alveolar consonants /ʃ, ʒ/ since they did not occur in our experiment in a word-final position.

CONCLUSION

This bachelor thesis aimed to examine the role of pre-fortis shortening in Czech English. First of all, a general overview of the English vocalic system was provided. Having introduced the quality of the English vowels to the reader in the first chapter, the thesis proceeded to the study of vocalic quantitative differences. Special attention was paid to the factors which proved to have an impact on vowel duration. A number of authors were cited and their results concerning vowel duration in various environments were contrasted. Subsequently, the function of English vowel duration was outlined and compared with the duration of vocalic sounds in Czech. This comparison enabled a smooth transition to the empirical part of the thesis which had as its objective to find out whether the correlation between vowel duration and the level of proficiency exists in Czech English. The durations of pre-fortis and pre-lenis vowels were measured within the three categories of participants: A2 level (higher secondary school students), C1 level (university students) and a category of native speakers.

The departure point for this thesis was a hypothesis that Czech students with a higher level of English will exploit pre-fortis clipping more than those with a lower English level who have not attended any course specialized in phonetics. The results indicate that the difference in vowel durations before fortis and lenis consonants was statistically significant in the C1 category. On the contrary, the differences in vowel durations of the respondents in the A2 category were almost negligible and were not proven to be statistically significant. Therefore, we can tentatively conclude that the original hypothesis that students with a higher level of English level will exploit the vowel lengthening or shortening to a greater extent was confirmed, however the differences were not as glaring as expected and the statistical analysis did not ascertain their significance.

Taking into consideration the results of the C1 group and comparing them with the data obtained from the native speakers, we can state that there is a tendency towards the native-like production, especially in the pronunciation of words where the final consonant is lenis. Although in voiceless environments, vowel duration was measured to be almost equal for all the three categories, the lenis members of the pair showed a significant difference between the two categories of Czech students and native speakers. This variation can be explained by the students' negative transfer from their mother tongue - Czech. They tend to pronounce all final consonants as voiceless which corresponds to the principle of regressive assimilation common in Czech, however, in English the vowels

may become devoiced in the final position but they retain their lenis character which is signalled by the longer duration of the preceding vowel.

Moreover, according to the results of the current experiment, pre-fortis shortening in Czech English turned out to be exploited to a larger extent in the category of lax vowels than in the category of tense vowels. As a result, English teachers in the Czech Republic should probably consider greater employment of pronunciation exercises in their classes focusing on the durational differences between the minimal pairs containing tense vowels such as *seat-seed, leaf-leave* etc.

Nevertheless, it should be borne in mind that due to the relatively small number of participants it is not possible to generalize and relate the obtained results to all students with either C1 or A2 level. Therefore, it would be interesting to continue in the research and extend the number of participants and possibly include also some students with either B1 or B2 level to find out whether the tendency is also rising in between the A2 and B1/2 levels. In addition, it would also be effective to focus on all vowels and diphthongs and to discover whether pre-fortis shortening in Czech English also manifests itself on the duration of the vowel schwa or centring diphthongs.

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APPENDICES

Appendix 1. Sentences for recording in the exact order in which they were given to the students.

1. How does a **duff** taste?
2. A lion **cub** was saved by a vet.
3. He stamped his **foot** with rage.
4. There was an **edge** to his voice.
5. My **bag** fell on the floor.
6. The **rich** keep getting richer.
7. I saw the **dock** next to the river.
8. The **mob** violence resulted in numerous injuries.
9. She **lit** the candle.
10. A gas **leak** was detected in his house.
11. She **laid** her hands on his shoulder.
12. I bought a pair of **brogue** shoes last week.
13. You're **safe** with me.
14. The **buzz** was very noisy.
15. Pass me the **rice** bag, please.
16. What's your **badge** number?
17. You cannot **hide** forever.
18. I bought a **robe** for the ball.
19. I **bet** you'll **lose** the game.
20. I took a **leaf** from **his** garden.
21. It's a **loose** translation.
22. I saw the **dog** barking at the **back** door.
23. The **bus** came **late** today.
24. His **cup** was filled with coffee.
25. I heard a **dove** singing.
26. This **lid** doesn't fit.
27. I **broke** my ankle.
28. The **hiss** was such an unpleasant noise.
29. He'll come and **save** them.
30. Your **height** might be genetic.
31. I bought a **rope** for the boat.
32. How can I **etch** the glass?
33. His **bed** was made of wood.
34. His behaviour gave **rise** to complaints.
35. I made a double **batch** for the party.
36. I took a **leave** from his garden.
37. Use the **mop** for cleaning.
38. This **food** makes you fat.
39. He was a Premier **League** player.
40. The **ridge** needs to be restored.

Appendix 2. Questionnaire.

Dotazník pro studenty angličtiny

1. Jakého jste pohlaví?
a) Muž b) Žena

2. Kolik je Vám let?
……

3. Jak dlouho se učíte anglicky?
……

4. Strávil/a jste v anglicky mluvící zemi delší dobu než jeden měsíc?
a) Ano b) Ne

Pokud ano, kdy....., jak dlouho…… a kde……. ?

5. Byl/a jste v poslední době v přímém kontaktu s rodilým mluvčím?
a) Ano b) Ne

Pokud ano, jak často?
a) Denně
b) 1x za týden
c) 1x za měsíc
d) Jiné
……

6. Sledujete pravidelně britské/americké seriály či filmy v originálním znění?
a) Ano b) Ne

Pokud ano, jak často?
a) Denně
b) Několikrát za týden
c) 1x za týden
d) 1x za měsíc
e) Jiné
…….....

Appendix 3. Average vowel durations obtained from both A2 and C1 categories and the category of native speakers (**v** stands for a voiced consonant, **unv** for a voiceless consonant, **P** stands for a following plosive, **F** for a following fricative and **A** for an adjacent affricate).

Vowels	Level	Voicing	Manner	Duration in ms
all	A2, C1	v, unv	P, F, A	102.68
all	A2, C1	v	P, F, A	106.53
all	A2, C1	unv	P, F, A	98.84
all	C1	v, unv	P, F, A	107.51
all	A2	v, unv	P, F, A	97.85
all	A2	v	P, F, A	100.32
all	A2	unv	P, F, A	95.38
all	C1	v	P, F, A	112.73
all	C1	unv	P, F, A	102.29
all	A2	v	P	104.77
all	A2	v	F	103.19
all	A2	v	A	75.87
all	A2	unv	P	96.44
all	A2	unv	F	100.8
all	A2	unv	A	78.46
all	C1	v	P	116.12
all	C1	v	F	114.65
all	C1	v	A	94.7
all	C1	unv	P	103.87
all	C1	unv	F	107.13
all	C1	unv	A	84.71
lax	A2, C1	v, unv	P, F, A	89.36
tense	A2, C1	v, unv	P, F	110.59
diphthongs	A2, C1	v, unv	P, F, A	125.82
lax	A2, C1	v	P, F, A	93.39
lax	A2, C1	unv	P, F, A	85.65
tense	A2, C1	v	P, F	111.75
tense	A2, C1	unv	P, F	109.05
diphthongs	A2, C1	v	P, F, A	129.34
diphthongs	A2, C1	unv	P, F, A	122.31
lax	A2	v, unv	P, F, A	83.04
tense	A2	v, unv	P, F	108.35
diphthongs	A2	v, unv	P, F, A	122.59
lax	C1	v, unv	P, F, A	95.68
tense	C1	v, unv	P, F	112.84
diphthongs	C1	v, unv	P, F, A	129.06
lax	A2, C1	v, unv	P	92.24
lax	A2, C1	v, unv	F	89.05
lax	A2, C1	v, unv	A	83.44

lax	A2, C1	v	P	98.33
lax	A2, C1	v	F	91.6
lax	A2, C1	v	A	85.29
lax	A2, C1	unv	P	87.02
lax	A2, C1	unv	F	86.49
lax	A2, C1	unv	A	81.59
lax	C1	unv	P	91.9
lax	C1	unv	F	89.43
lax	C1	unv	A	84.71
lax	C1	v	P	107.93
lax	C1	v	F	98.22
lax	C1	v	A	94.7
lax	C1	v	P, F, A	102.19
lax	C1	unv	P, F, A	89.67
lax	A2	unv	P	82.14
lax	A2	unv	F	83.56
lax	A2	unv	A	78.46
lax	A2	v	P	88.73
lax	A2	v	F	84.98
lax	A2	v	A	75.87
lax	A2	v	P, F, A	84.58
lax	A2	unv	P, F, A	81.62
tense	A2, C1	v, unv	P	106.99
tense	A2, C1	v, unv	F	113.29
tense	A2, C1	v	P	103.07
tense	A2, C1	v	F	120.42
tense	A2, C1	unv	P	114.83
tense	A2, C1	unv	F	106.16
tense	A2	v	P, F	110.68
tense	A2	unv	P, F	105.23
tense	A2	unv	P	115.69
tense	A2	unv	F	100
tense	A2	v	P	102.41
tense	A2	v	F	118.95
tense	C1	unv	P, F	112.87
tense	C1	v	P, F	112.81
tense	C1	unv	P	113.96
tense	C1	unv	F	112.32
tense	C1	v	P	103.73
tense	C1	v	F	121.9
diphthongs	A2, C1	v, unv	P	125.89
diphthongs	A2, C1	v, unv	F	125.69
diphthongs	A2, C1	v	P	132.31
diphthongs	A2, C1	v	F	123.39
diphthongs	A2, C1	unv	P	119.48
diphthongs	A2, C1	unv	F	127.98

diphthongs	C1	unv	P	122.29
diphthongs	C1	unv	F	128.48
diphthongs	C1	v	P	134.61
diphthongs	C1	v	F	132.06
diphthongs	C1	v	P, F	133.76
diphthongs	C1	unv	P, F	124.35
diphthongs	A2	unv	P	116.66
diphthongs	A2	unv	F	127.48
diphthongs	A2	v	P	130
diphthongs	A2	v	F	114.73
diphthongs	A2	v	P, F	124.91
diphthongs	A2	unv	P, F	120.27

Native speakers

Vowels	Country of origin	Voicing	Manner	Duration in ms
all	UK, USA	v, unv	P, F, A	129.87
all	UK, USA	v	P, F, A	155.59
all	UK, USA	unv	P, F, A	104.14
all	UK, USA	v, unv	P	131.12
all	UK, USA	v, unv	F	138.67
all	UK, USA	v, unv	A	104.31
all	UK, USA	v	P	156.84
all	UK, USA	v	F	163.58
all	UK, USA	v	A	131.97
all	UK, USA	unv	P	105.4
all	UK, USA	unv	F	113.76
all	UK, USA	unv	A	76.65
all	UK	v	P	167.15
all	UK	v	F	185.12
all	UK	v	A	121.7
all	UK	unv	P	110.27
all	UK	unv	F	124.58
all	UK	unv	A	70.36
all	USA	v	P	146.54
all	USA	v	F	142.04
all	USA	v	A	142.24
all	USA	unv	P	100.53
all	USA	unv	F	102.95
all	USA	unv	A	82.93
lax	UK, USA	v, unv	P, F, A	117.99
tense	UK, USA	v, unv	P, F	141.35
diphthongs	UK, USA	v, unv	P, F, A	147.9
lax	UK, USA	v	P, F, A	147.34
lax	UK, USA	unv	P, F, A	90.9

tense	UK, USA	v	P, F	168.5
tense	UK, USA	unv	P, F	105.15
diphthongs	UK, USA	v	P, F, A	163.5
diphthongs	UK, USA	unv	P, F, A	132.31
all	UK	v, unv	P, F, A	138.02
lax	UK	v, unv	P, F, A	114.28
tense	UK	v, unv	P, F	163.34
diphthongs	UK	v, unv	P, F, A	172.73
all	USA	v, unv	P, F, A	121.71
lax	USA	v, unv	P, F, A	121.71
tense	USA	v, unv	P, F	119.36
diphthongs	USA	v, unv	P, F, A	123.08
lax	UK, USA	v, unv	P	120.6
lax	UK, USA	v, unv	F	126.03
lax	UK, USA	v, unv	A	104.31
lax	UK, USA	v	P	151.54
lax	UK, USA	v	F	154.31
lax	UK, USA	v	A	131.97
lax	UK, USA	unv	P	94.08
lax	UK, USA	unv	F	97.75
lax	UK, USA	unv	A	76.65
lax	UK	v	P, F, A	144.83
lax	UK	unv	P, F, A	81.7
lax	UK	v	P	148.19
lax	UK	v	F	161.24
lax	UK	v	A	121.7
lax	UK	unv	P	84.39
lax	UK	unv	F	105.72
lax	UK	unv	A	70.36
lax	USA	v	P, F, A	149.85
lax	USA	unv	P, F, A	95.73
lax	USA	v	P	154.89
lax	USA	v	F	147.38
lax	USA	v	A	142.24
lax	USA	unv	P	103.77
lax	USA	unv	F	89.77
lax	USA	unv	A	82.93
tense	UK, USA	v, unv	P	133.68
tense	UK, USA	v, unv	F	147.1
tense	UK, USA	v	P	161.79
tense	UK, USA	v	F	175.22
tense	UK, USA	unv	P	77.48
tense	UK, USA	unv	F	118.99
tense	UK	v	P, F	205.44
tense	UK	unv	P, F	107.21
tense	UK	v	P	203.64

tense	UK	v	F	207.25
tense	UK	unv	P	71.01
tense	UK	unv	F	125.31
tense	USA	v	P, F	131.56
tense	USA	unv	P, F	103.09
tense	USA	v	P	119.94
tense	USA	v	F	143.18
tense	USA	unv	P	83.95
tense	USA	unv	F	112.66
diphthongs	UK, USA	v, unv	P	147.25
diphthongs	UK, USA	v, unv	F	149.21
diphthongs	UK, USA	v	P	162.32
diphthongs	UK, USA	v	F	165.84
diphthongs	UK, USA	unv	P	132.18
diphthongs	UK, USA	unv	F	132.57
diphthongs	UK	v	P, F	184.5
diphthongs	UK	unv	P, F	160.96
diphthongs	UK	v	P	177.34
diphthongs	UK	v	F	198.81
diphthongs	UK	unv	P	165.38
diphthongs	UK	unv	F	152.12
diphthongs	USA	v	P, F	142.5
diphthongs	USA	unv	P, F	103.66
diphthongs	USA	v	P	147.31
diphthongs	USA	v	F	132.88
diphthongs	USA	unv	P	98.98
diphthongs	USA	unv	F	113.01

Appendix 4. The whole set of the obtained recordings on the enclosed DVD.